Fig 1

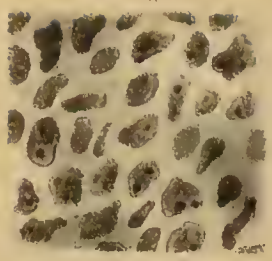

Fig 2

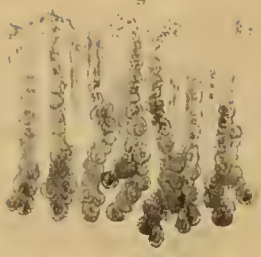

Fig 3

Fig 4

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Fig 7

Fig 6

Fig 8

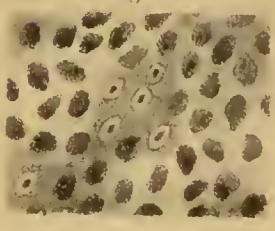


Fig 9

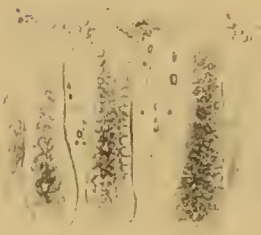


Fig 10

Fig 11

Fig 15

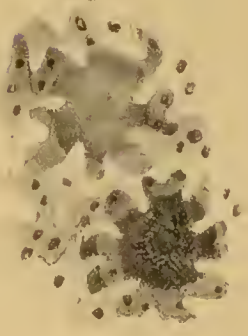


Fig 12

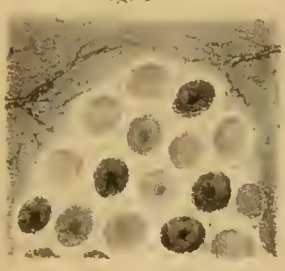


Fig 14

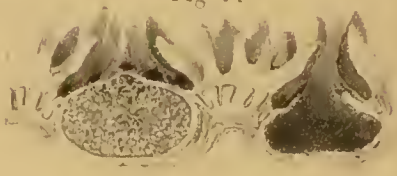
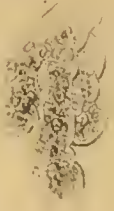


Fig 19

Fig 13

Fig 16

Fig 17



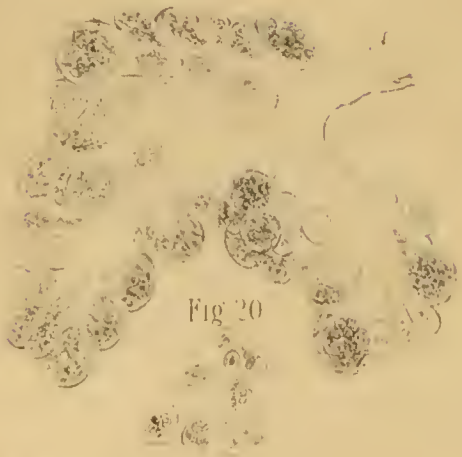
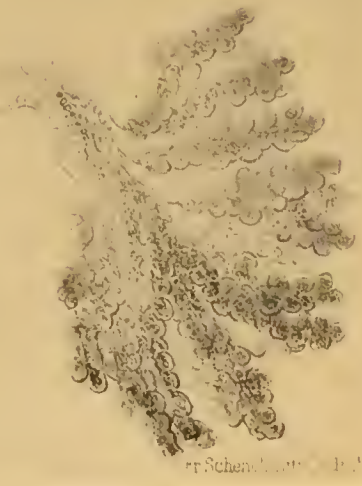


Fig 20

Fig 18



Allen Thomson del.

Gland of the Alimentary Canal

IV.—*On the Structure of the Glands of the Alimentary Canal.*

By Allen Thomson, M.D., F.R.C.S.E., F.R.SS. Lond. and Edin., and Professor of Anatomy in the University of Glasgow.—(Communicated by the Author.)

(Plate III.)

The minute and extended secretory apparatus contained in the mucous membrane of the alimentary canal presents considerable variety of structure, and is of great interest in relation both to the natural process of digestion and to the pathological changes to which that function is liable. The different parts of this apparatus have in recent years been subjected to careful examination by most able observers,[1] but as yet without leading to a complete knowledge of their structure and uses. There

[1] The following references to works on the intestinal glands and mucous membrane will serve to indicate in some measure the sources of information and progress of investigation on this subject :—

J. C. Peyer, Exercit. Anat. de Gland. Intestin. Shafthausen, 1677.
J. C. Brunner, de Gland. in Intestino Duodeno Detect. Heidelberg, 1687.
J. N. Lieberkühn, de Fab. et Act. Villorum Intestin. Leyden, 1745, and Lond. 1782.
R. A. Hedwig, Disquis. Ampull. Lieberkühn. &c. Leipzig. 1797.
Rudolphi, Anat. Physiol. Abhandl. Berlin. 1802.
E. H. Weber, in Meckel's Archiv., 1827; and Entfaltung der Drüsengebilde. 1828.
J. Müller, Comment. de Gland. Secern. Struct. Penit. Berol. 1830.
Boehm, de Gland. Intestin. Struct. Penit. Berol, 1835, and also of the same author, Die Kranke Darmschleimhaut in Asiat. Cholera. Berlin. 1838.
Sprott Boyd, in Edin. Med. and Surg. Journ. 1836.
Henle, Symb. ad Villor. Intestin. Hist. 1837.
Bischoff, in Müller's Archiv. 1838, p. 513.
Purkinje, Bericht d. Naturf. in Prag. Isis, 1838.
A. Anderson, in Medical Gazette. 1838.
Krause, in Müller's Archiv. 1837 and 1839.
Wasmann, Dissert. nonnulla de Digestione, &c. 1839.
Pappenheim, Zur Kenntniss der Verdauung, &c. Berlin, 1839.
Todd, in Medical Gazette. 1839.
Müller's Physiology by Baly, and Notes by the latter, vol. i. p. 583, &c. 1840.
Allen Thomson, in Report of Brit. Assoc., 1840, p. 149.
Henle, Allgemeine Anatomie. 1841.
Bowman, in Article "Mucous Membrane" in Todd's Cyclopædia. 1842.
Huschke, Splanchnologie. 1845.
John Goodsir, Anat. and Path. Observations. Edinburgh, 1845.
Sharpey, in Quain's Anat. p. cexevii. and p. 1025, &c. 1848.
Frerichs, Article Verdauung in Wagner's Handworterbuch der Physiol. 1849.

are several difficulties opposed to the accurate investigation of the mucous glands of the alimentary canal. In addition to their small size and the softness of their texture, their great tendency to have their appearance rapidly altered after death, and their liability during life to change from age and long continued disease are among the most important. A satisfactory examination of these glands can in general, therefore, be made only in specimens which are quite recent, and which have been procured from the bodies of young persons, and from those who have died suddenly either from accident or from some disease proving rapidly or immediately fatal.

Since the year 1839, when the completion of the discovery of the cellular nature of many of the textures gave to the study of histology the greatest impulse it has received in recent times, I have been repeatedly occupied with the examination of the minute glands of the alimentary canal. In the year 1840, I laid before the meeting of the British Association, held at Glasgow, an account of some researches I had then made on this subject, and a brief notice of my paper was inserted in the Report of the Transactions of the Association for that year. I abstained from publishing a more detailed account of the observations, because of their being at that time incomplete. The learned Editor of these Annals having expressed a wish that I should now communicate my observations on the subject in this Journal, I have revised them in so far as my present limited time and opportunities permit, and I now offer some of them with great diffidence, as a contribution to the history of this extended secretory apparatus; the full and accurate investigation of which, from the circumstances already alluded to, requires the most entire leisure, together with the most favourable specimens and methods of observation.

In the paper laid before the meeting of the British Association in 1840, besides a general description of the structure of the mucous membrane of the alimentary canal and of its various glandular bodies, the following facts were more particularly dwelt upon as resulting from my observations.

1. That the vesicles which constitute the aggregated form of

Peyer's glands not unfrequently exhibit openings, so distinct, and occurring under such determinate circumstances, as to warrant the belief that they are the natural way by which the secreted contents of these vesicles are discharged. These apertures I observed frequently in the pig, sheep, horse, and some other animals, and occasionally in the adult human subject—but not in the young. The openings, which on the small scale might be compared to the pupil in the iris, are visible with the unassisted eye, and more easily with a hand-lens; and the vesicles in which they are seen, are either completely or partially empty of the granular matter with which the closed ones are filled. In the pig, in which the greatest number of observations were made, it was found that in some patches no open vesicles were to be detected; while in others, almost all were open and empty; and in a third set, open and closed vesicles were irregularly placed together in the same patch.

The open vesicles were observed more frequently in the ileum than in the upper part of the intestine, and it appeared to be in those parts of the intestine which contained the more fluid, dark-coloured and bilious matter, that the open vesicles were almost invariably found; while in those parts of the gut which contained a light-coloured chymous or chylous mass, which were more contracted, and in which the coats appeared thickened by the imbibition of the chyle, the vesicles were all closed and full of their usual contents.

I considered these observations, which confirmed those made by Krause and others, as not only of interest in regard to the explanation of the secretory function of these vesicular glands, but as also bearing in an important manner on the then recently produced views of the nature of the process of secretion in general; as they tended to shew, that in some forms of glands, the closed condition of the secretory vesicles most commonly prevailed, and that the open state was of rarer occurrence.

2. I had farther observed that the solitary glands, or larger follicles, of the colon, which are almost always open in the adult, are, at the period of birth, all closed by a thin bulging film of membrane, which gives them the form of true vesicles:

and that as the early age of the infant advances, more and more of these follicles assume the permanently open condition: but even after the age of two years, I occasionally found some of the follicles still closed, or presenting the vesicular form.

3. My observations also led me to believe that the gastric follicular glands have at an early period of life the same closed condition. By these I do not mean the thick set and more numerous tubular glands of which the whole thickness of the gastric mucous membrane may be said to be composed, but the more sparsely distributed shallow pits or follicles, about 1-20th of an inch in diameter, which are sometimes seen studding the greater part of the gastric mucous membrane.

Considerable difference of opinion has existed among anatomists and pathologists, as to whether this appearance of scattered follicles over the gastric mucous membrane is natural or not. I conceived that I had shewn by the examination of persons of different ages, who died suddenly or from acute diseases, not involving any morbid state of the alimentary canal, that the existence of these follicles over nearly the whole surface of the stomach, is most probably the natural condition; and I had reason to believe that the representations given by several authors of enlarged and ulcerated gastric follicles were not fallacious, but were those of true examples of morbid alterations of these scattered, or so called solitary glands of the stomach.[1]

I also observed that these scattered follicular glands of the stomach were closed in the form of vesicles in early life. This I found to be the case in the stomach of a child of eight months old; and still more remarkably in the pig, two or three weeks after birth. In this animal, the gastric follicular glands, which are chiefly to be found in the cardiac portion of the stomach, numerously spread over the mucous membrane near the border of the thick laminated epithelium, which extends for some way into the stomach from the œsophagus, are formed of compound or sacculated follicles; and it was therefore peculiarly interesting to find that in their early and simpler condition they had, like those of the large intestine, the form of closed vesicles. In

[1] As by Roederer and Wagler, Cruveilhier and others.

the stomach of the pig of between two and three weeks old, only two of the gastric follicles had become open, all the others, which were numerous, still retained the closed or vesicular condition. In the stomach of the human infant of sixteen months old, a few of the gastric follicles were observed still to be closed, but the greater number were then open.

I had also noticed repeatedly the occurrence in adult life in the human stomach, and more rarely in the large intestine, of small clear vesicles, on various parts of the surface of the mucous membrane, an appearance previously observed by Boehm, Bischoff, and Henle. I was doubtful whether these vesicles were identical with the closed follicles, to which they have by some been compared; but I thought that I had occasionally perceived a few of the solitary follicles, both of the stomach and colon, exhibiting the closed condition even in the adult human subject. More recent observations have not enabled me to determine this point; but I am inclined to doubt the propriety of comparing these vesicles to the lenticular or vesicular glands, such as those of Peyer, as has recently been done by Frerichs in the article Verdauung of Wagner's Handworterbuch der Physiologie. To this article I would refer, however, as containing a short but most accurate account of the structure of the glandular apparatus of the alimentary canal, with which the greater part of my observations very closely coincide. I have not had an opportunity of seeing a more extended account of researches on this subject by Drs. Frerichs and Frey, to which the former refers in a note at p. 742 of his article on Digestion.

More recent observations by others and by myself, enable me now to correct and to modify in some particulars, the description I previously gave of these glands, and to render our knowledge of them somewhat more precise.

Some ambiguity prevails as to the nomenclature of the minute glands and their parts, in consequence of the various use that has been made by different authors of the terms follicle, crypt, saccule, lacuna, vesicle, cell and others. The words vesicle, follicle, tube or tubule, and raceme or cluster, appear sufficiently descriptive and precise, when taken in their ordi-

nary signification, to warrant their employment for the purpose of distinguishing the principal forms of glands occurring in the alimentary canal, under the four heads of Vesicular, Follicular, Tubular, and Racemose Glands. The following is an enumeration of the various glandular structures, to the number of ten, which may be brought under this fourfold classification :—

I. Vesicular; composed of entire vesicles (or small bladders); usually closed.

1. Aggregated glands of Peyer in the small intestine.
2. Solitary ditto.
3. An occasional state of the next mentioned glands.

II. Follicular; forming small bags or cavities; usually open pits.

1. Of the large intestine; constant.
2. Of the stomach; frequent but not constant.

III. Tubular; composed of membranous tubes, closed at the remote ends, and usually simple.

1. Of the small intestine: Follicles of Lieberkühn.
2. Of the large intestine.
3. Of the stomach.

IV. Racemose; tubes, simple or sacculated, (and vesicles,) arranged in clusters round a central stalk or duct.

1. Cardiac-œsophageal.
2. Duodenal of Brunner.

In this enumeration of the stomachal and intestinal glands, there is in some measure a progression from the simpler to the more complex; for the single and distinct vesicles of which the solitary and aggregated kinds of Peyer's glands consist (*Figs.* 12, 13, and 14) may be regarded as the most elementary form of enclosing cavity for a glandular secreting organ. The follicles, mentioned in the second place, consisting in their simplest form of mere depressions of the surface of the mucous texture, (*Fig.* 11,) have originally been, according to what I have previously stated, in the condition of closed vesicles,—a condition which some of them continue occasionally to exhibit in adult life. The tubes, which are placed in the third order, consist in deeper and more cylindrical inflections of the proper or basement mem-

brane of the mucous texture, of great delicacy, and of variable form and extent. This is the form of minute glands now so well known to occupy the whole of the mucous membrane from the cardia to the anus, and which are so thickly set as to appear on a superficial examination to constitute the whole of its substance. The tubules of the large intestine, (*Figs.* 8 and 9,) are longer than those of the small intestine, (*Figs.* 5 and 6,) and those of the stomach, besides being considerably larger than either, are also more complicated, exhibiting frequently a sacculated, and occasionally, though rarely, a subdivision or simple ramification at their remote extremities. (*Figs.* 1, 2, and 3, in which, however, this appearance is more marked than usual.) The gastric tubular glands thus form in some sort a transition to the fourth set, in which the clustering or collecting together of ramified and sacculated tubes, (*Figs.* 16 and 17,) or of pediculated vesicles, (*Fig.* 19,) constitutes the essential character. The last mentioned form, which occurs in Brunner's glands, bears a close resemblance to the structure of the pancreas, salivary, and other compound racemose glands; but the amount of dilatation of the ends of the tubes varies to a great extent in different glands.

In the minute tubular glands of the small and large intestine, in those of the stomach, and in the racemose glands of the cardia and duodenum, the basement membrane, which constitutes the delicate walls of the tubular and sacculated cavities within the glands, is nearly homogeneous, slightly studded with nuclei or small dark particles of variable size, and presenting altogether an appearance not very dissimilar from the continuous parts of the mucous membrane itself. The membrane composing the wall of the vesicles of Peyer's glands, on the other hand, and also that of the bottom of the follicles of the large intestine, is considerably thicker than that of the tubular and racemose glands, and differs from it likewise in its more granular aspect and in its close incorporation at the lower part with the subjacent filamentous tissue. The follicular glands of the stomach appear to consist merely of depressions among the tubes in the otherwise unchanged mucous membrane. In that state of the gastric

and large-intestinal follicles in which they present the so-called *lenticular* or closed vesicular form, the closing film, which is of extreme delicacy and great clearness, seems to be a completely homogeneous or structureless membrane.

The columnar epithelium, which everywhere invests the surface of the mucous membrane, extends for some way into the interior of the follicular, tubular, and racemose glands; but no true lining of this kind, different from their secreted contents, exists in the vesicular glands: indeed, these last are probably to be looked upon rather as a modification of parent secreting cells, than as true glandular cavities.

The secreted product of all these glands, presenting to the naked eye the appearance of a greyish, grumous, semifluid mass, exhibits, when viewed with the microscope, a variety of cells mixed with globules, granules, and molecules of various size. The cells contained in the vesicles of Peyer's glands, and in the mucous tubules of the small and large intestine, appear in general to be considerably smaller and more granular in their aspect than those of the tubular gastric, or of the racemose cardiac and duodenal glands. (Compare *figs*, 7, 10, and 15, with *figs.* 4, 18, and 20.) The following are the average results in parts of an inch of a few measurements I have made of the size of the cellular contents of these glands in the human subject:—

Gastric tubular glands, 1-1500th to 1-1200th.
Cardiac-œsophageal racemose glands, 1-1600th.
Brunner's duodenal glands, 1-2000th to 1-1700th.
Aggregate Peyer's glands, 1-2500th to 1-2000th.
Tubular glands of the colon, 1-2500th.
Tubular glands of the jejunum, 1-3000th to 1-2800th.

In the vesicles of Peyer's glands, there is great uniformity in the appearance of the cellular contents; in these and in the tubular glands of the small and large intestines, the cells present very generally a granular aspect; but in the latter they are sometimes mixed with larger and more distinct cells and a quantity of smaller molecules.

In the tubular gastric glands, and in the racemose cardiac and duodenal glands, the larger cells which prevail, exhibit for

the most part a distinct external wall, with one or more internal cells, sometimes clear, at other times granular, with nuclei and nucleoli of various appearance.

In the healthy gastric glands, these cells are, during the intervals of digestion, accumulated in considerable quantity in the tubes, so as to cause the membrane of the tubes to bulge out at somewhat regular intervals, and thus to give them the sacculated appearance represented in *Figs.* 2 and 3. In the human stomach, but more especially in that of the dog, cat, and pig, I have frequently seen these cells placed more closely in contact with the basement membrane of the tubes, while the central part was occupied by a mass of smaller cells and granules. These gastric cells are poured out in large quantity on the surface of the mucous membrane during digestion, and may also be frequently seen to exude anew after death, being united by imbibed water so as to form a layer of substance, indefinitely termed mucus, which has often been noticed covering the inner surface of the stomach. The microscopic examination of this layer sometimes affords a most interesting view of the gastric cells in all stages of development or decadence; smaller cells existing within the larger ones to the second and third progeny; and thus very probably furnishing, as Frerichs suggests, the source of that ferment, or analogous matter, which, along with the acid ingredient of the gastric fluid, is essential to the solvent action of stomachal digestion.

In the racemose kinds of glands previously adverted to, a somewhat similar arrangement of the secreted cells is observed. In the duodenal glands, I thought I could perceive in some terminal ducts, the gland-cells enclosed within a vesicular membrane or large cell, of the same size with the dilated ends of the ducts; but this would require farther confirmation.

The limited form of this communication makes it necessary for me to conclude. I beg leave for the present to refer the reader to the description of the Plate for some farther details as to the structure of these glands, and should it appear desirable, I may hereafter continue the account of my observations in regard to them. With the general knowledge that has

now been obtained of the distribution and structure of these glands, it seems desirable that hereafter more exact and extended researches should be made with reference to their variations in different circumstances, according to the state of general health of the individual, the age, the period of digestion or fasting, the contents of the alimentary canal, and the food or habits of various animals in which they may be examined, with a view to the more just physiological and pathological application of the information derived from the study of their structure.

Description of Plate III.

Fig. 1. Small portion of the mucous membrane of the human stomach from the middle part, showing the shallow alveolar pits, and in some of these the apertures of the tubular glands: from an epileptic who died suddenly when in good bodily health;—magnified 30 diameters.

Fig. 2. Vertical section of a similar piece, showing a few of the tubular glands filled with cells and granular matter;—magnified 30 diameters. The appearance of ramification is somewhat deceptive or exaggerated.

Fig. 3. Deeper portion of two of these tubular glands;—magnified 65 diameters; showing in some parts the membrane of the tubes, and the manner in which it is bulged out, or saeculated, at various places by the cellular contents.

Fig. 4. Cellular contents of the gastric tubular glands;—magnified 250 diameters. *a* from the human stomach; *b* from that of the pig.

Fig. 5. Small portion of the inner surface of the human jejunum from an adult;—magnified 30 diameters. Several villi are seen lying flat on the surface, and between them the apertures of a number of Lieberkühn's follicles, or the tubular glands: the villi are denuded of their epithelial covering; and most of the tubuli have also lost their epithelial lining; a few, however, are seen in which it remains at the mouths, thus contracting greatly their aperture.

Fig. 6. Vertical section of a portion of the same;—magnified 65 diameters. Two villi and five tubuli are seen: *a* the opening of the middle one of the five tubuli, nearly empty, showing the basement membrane; the other tubes are more or less filled with cellular and granular contents; *b* a few columnar particles of epithelium adhering to one of the villi.

Fig. 7. Granular cells contained in the tubuli of the small intestine of a man who died suddenly;—magnified 250 diameters.

Fig. 8. Small portion of the inner surface of the human colon, showing the

apertures of the tubular glands, most of which are divested of their epithelial lining, but in a few it is seen remaining;—magnified 30 diameters.

Fig. 9. Vertical section of three of these simple tubes; magnified 65 diameters: one of the tubes is full of epithelium and granular cells; the other two are partly emptied, and exhibit in some places the simple basement membrane.

Fig. 10. Granular cells contained in the tubuli of the large intestine;—magnified 250 diameters.

Fig. 11. Vertical section (diagram) of one of the follicular glands, and the adjacent tubules of the human colon, magnified about 6 diameters.

Fig. 12. Portion of a patch of Peyer's vesicular glands from the ileum of the pig, seen from the deep surface; the serous, muscular, and areolar coats being dissected off;—magnified about 3 diameters. The darker vesicles are open and empty, the paler are closed and full.

Fig. 13. Two of these vesicles, viewed from the inner surface of the intestine;—magnified about 15 diameters. One vesicle is closed and full, the other open and empty: in their vicinity are seen villi and the apertures of numerous mucous tubules.

Fig. 14. Vertical section of the same.

Fig. 15. Cellular contents of the vesicles of Peyer's glands;—magnified 250 diameters.

Fig. 16. One of the smallest of the cardiac-œsophageal glands from a man who died of apoplexy, magnified 30 diameters. The branched and sacculated tubes are seen filled with their cellular contents, and their communication with the main excretory duct may be traced: the latter is partially lined with short columnar epithelium.

Fig. 17. Portion of the closed extremity of one of the tubes of the same gland, magnified 65 diameters, showing the basement membrane of the tube and its contained cells.

Fig. 18. The cells of the same;—magnified 250 diameters.

Fig. 19. A small portion of one of Brunner's duodenal glands, from the human subject;—magnified 65 diameters. This specimen shows the more vesicular form of the remote extremities of the glandular tubes, and their communications with one of the branches of the main excretory duct. In some of the vesicular ends of the tubes the contained cells have the appearance of being enclosed within an external delicate cell.

Fig. 20. Cells of Brunner's glands isolated;—magnified 250 diameters.